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CASA DIABLO G-E-M

RESOURCES AREA

(GRA NO. CA-06)

TECHNICAL REPORT

(WSA CA 010-082)

Contract YA-553-RFP2-1054

Prepared By

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For

Bureau of Land Management
Denver Service Center
Building 50, Mailroom
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Denver, Colorado 80225

Final Report

April 22, 1983

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ATTACHMENTS
(At End of Report)

CLAIM AND LEASE MAPS

Patented/Unpatented

Geothermal

MINERAL OCCURRENCE AND LAND CLASSIFICATION MAPS (Attached)

Metallic Minerals

Uranium and Thorium

Nonmetallic Minerals

Geothermal

LEVEL OF CONFIDENCE SCHEME

CLASSIFICATION SCHEME

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

EXECUTIVE SUMMARY

The Casa Diablo Geology-Energy-Minerals (GEM) Resource Area (GRA) is about ten miles north of Bishop, in Mono County, California, covering the south end of the Benton Mountains and part of the "volcanic tablelands". There is one Wilderness Study Area (WSA) in it: CA 010-082.

In a small part of the GRA and a small part of the WSA metamorphosed sedimentary rocks 200 million to 500 million years old are exposed, together with granitic rocks intruded into them about 100 million years ago. The remainder of the GRA and the WSA are covered by volcanic ash rocks erupted a few hundred thousand years ago, with some areas of very recent sand and gravels.

Part of the Chidago mining district lies in the northwestern corner of this GRA. Two mines within the GRA have produced about $100,000 in precious and base metals, while the district as a whole has produced about $1 million in precious and base metals, as well as at least 250,000 tons of tungsten ore averaging 0.5% WO_3. Tungsten is a critical metal.

There are no patented mining claims in the GRA, and only a few dozen unpatented claims. Most of the unpatented claims are a mile or two west or north of WSA CA 010-082, but the W 1/2 Sec. 35, T 3 S, R 31 E, within the WSA, has unpatented claims. All of these claims are probably on precious and metal-base metal occurrences similar to those that have been mined. In the northeast corner of the GRA there are claims that probably cover occurrences of a fine, silty material that has been produced in the past as a filler for specialty asphaltic mixes.

There are no oil and gas, geothermal, or sodium or potassium leases in the GRA.

WSA CA 010-082 is classified throughout as moderately favorable for metallic mineral resources, with a moderate level of confidence. It is classified throughout as having low favorability for both uranium/thorium and nonmetallic minerals, with low confidence. It is classified as having moderate favorability for geothermal resources, with a low level of confidence. There is very low favorability with high confidence for oil and gas and for sodium and potassium resources.

Field work is recommended to determine whether there is alteration in the rocks of WSA CA 010-082 that might indicate metallic mineral resources, and to map alteration if it is present.

I. INTRODUCTION

The Casa Diablo G-E-M Resources Area (GRA No. CA-06) contains approximately 102,000 acres (412 sq km) and includes the following Wilderness Study Area (WSA):

WSA Name	WSA Number
Casa Diablo	010-082

The GRA is located in California in the Bureau of Land Management's (BLM) Bishop Resource Area, Bakersfield district. Figure 1 is an index map showing the location of the GRA. The area encompassed is near 37°35' north latitude, 118°30' west longitude and includes the following townships:

T 4 S, R 31,32 E T 5 S, R 31,32 E

The areas of the WSA are on the following U. S. Geological Survey topographic map:

15-minute:
Casa Diablo

The nearest town is Bishop which is located approximately 10 miles southeast of the GRA. Access to the area is via U.S. 6 to the east, Watterson Canyon road to the west, and U.S. 395 to the southwest. Access within the area is along various paved and unimproved roads such as Red Rock Canyon and Fish Slough Roads.

Figure 2 outlines the boundaries of the GRA and the WSA on a topographic base at a scale of 1:250,000.

Figure 3 is a geologic map of the GRA and vicinity, also at 1:250,000. At the end of the report, following the Land Classification Maps, is a geologic time scale showing the various geologic eras, periods and epochs by name as they are used in the text, with the corresponding age in years. This is so that the reader who is not familiar with geologic time subdivisions will have a comprehensive reference for the geochronology of events.

This GRA Report is one of fifty-five reports on the Geology-Energy-Minerals potential of Wilderness Study Areas in the Basin and Range Province, prepared for the Bureau of Land Management by the Great Basin GEM Joint Venture.

The principals of the Venture are Arthur Baker III, G. Martin

Booth III, and Dennis P. Bryan. The study is principally a literature search supplemented by information provided by claim owners, other individuals with knowledge of some areas, and both specific and general experience of the authors. Brief field verification work was conducted on approximately 25 percent of the WSAs covered by the study.

The WSA in this GRA was not field checked.

One original copy of background data specifically applicable to this GEM Resource Area Report has been provided to the BLM as the GRA File. In the GRA File are items such as letters from or notes on telephone conversations with claim owners in the GRA or the WSA, plots of areas of Land Classification for Mineral Resources on maps at larger scale than those that accompany this report if such were made, original compilations of mining claim distribution, any copies of journal articles or other documents that were acquired during the research, and other notes as are deemed applicable by the authors.

As a part of the contract that resulted in this report, a background document was also written: Geological Environments of Energy and Mineral Resources. A copy of this document is included with the GRA File to this GRA report. There are some geological environments that are known to be favorable for certain kinds of mineral deposits, while other environments are known to be much less favorable. In many instances conclusions as to the favorability of areas for the accumulation of mineral resources, drawn in these GRA Reports, have been influenced by the geology of the areas, regardless of whether occurrences of valuable minerals are known to be present. This document is provided to give the reader some understanding of at least the most important aspects of geological environments that were in the minds of the authors when they wrote these reports.

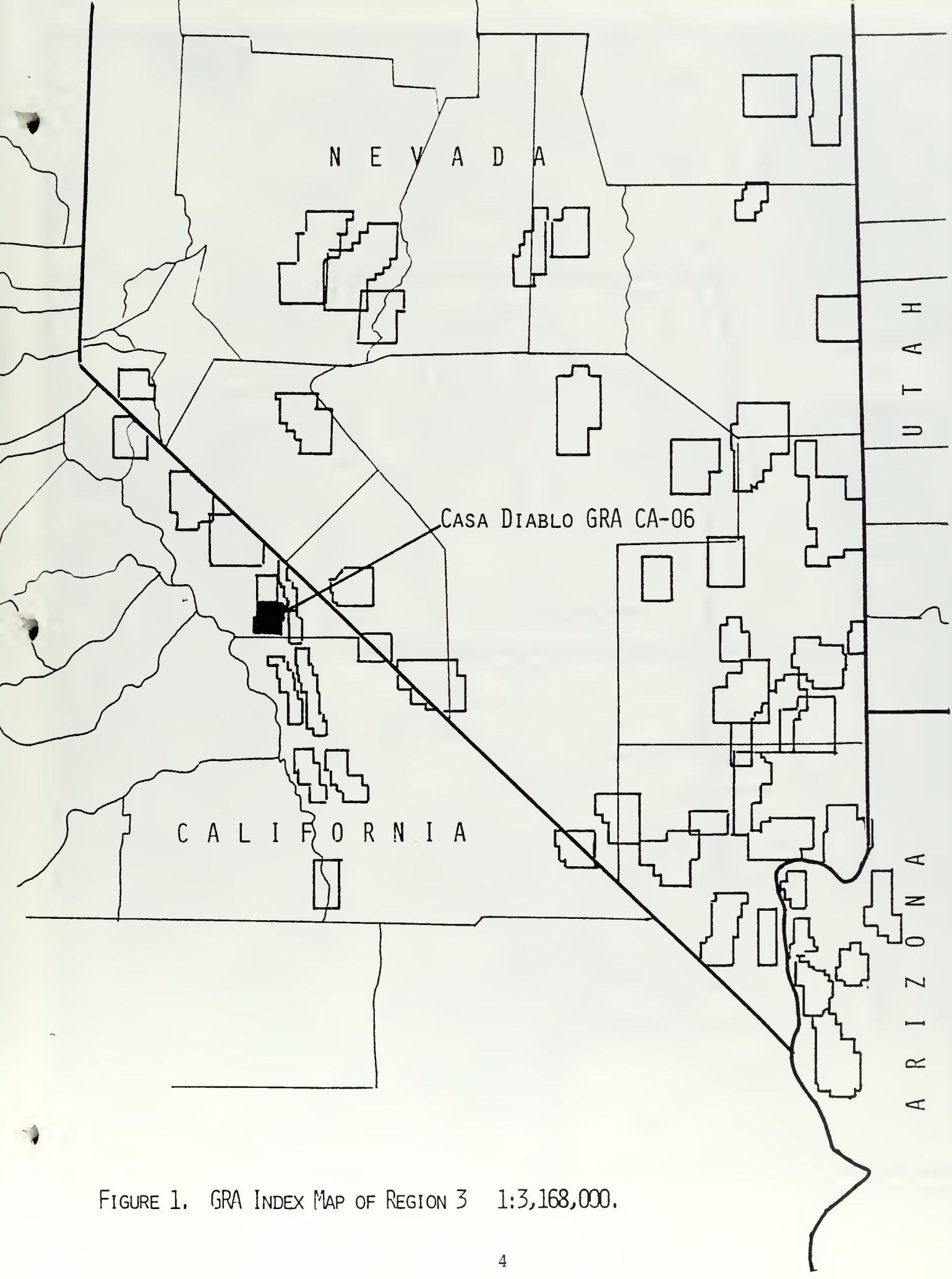
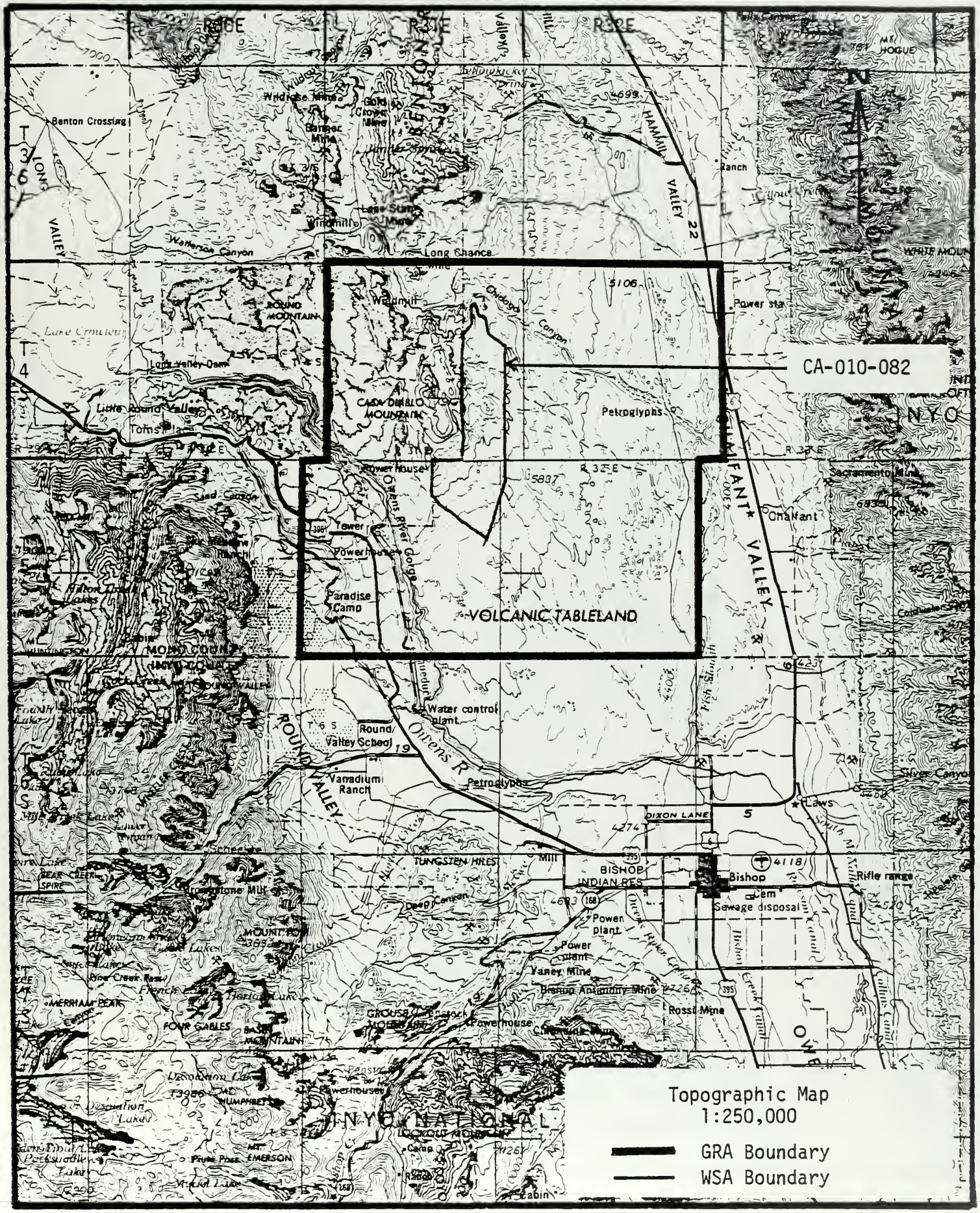


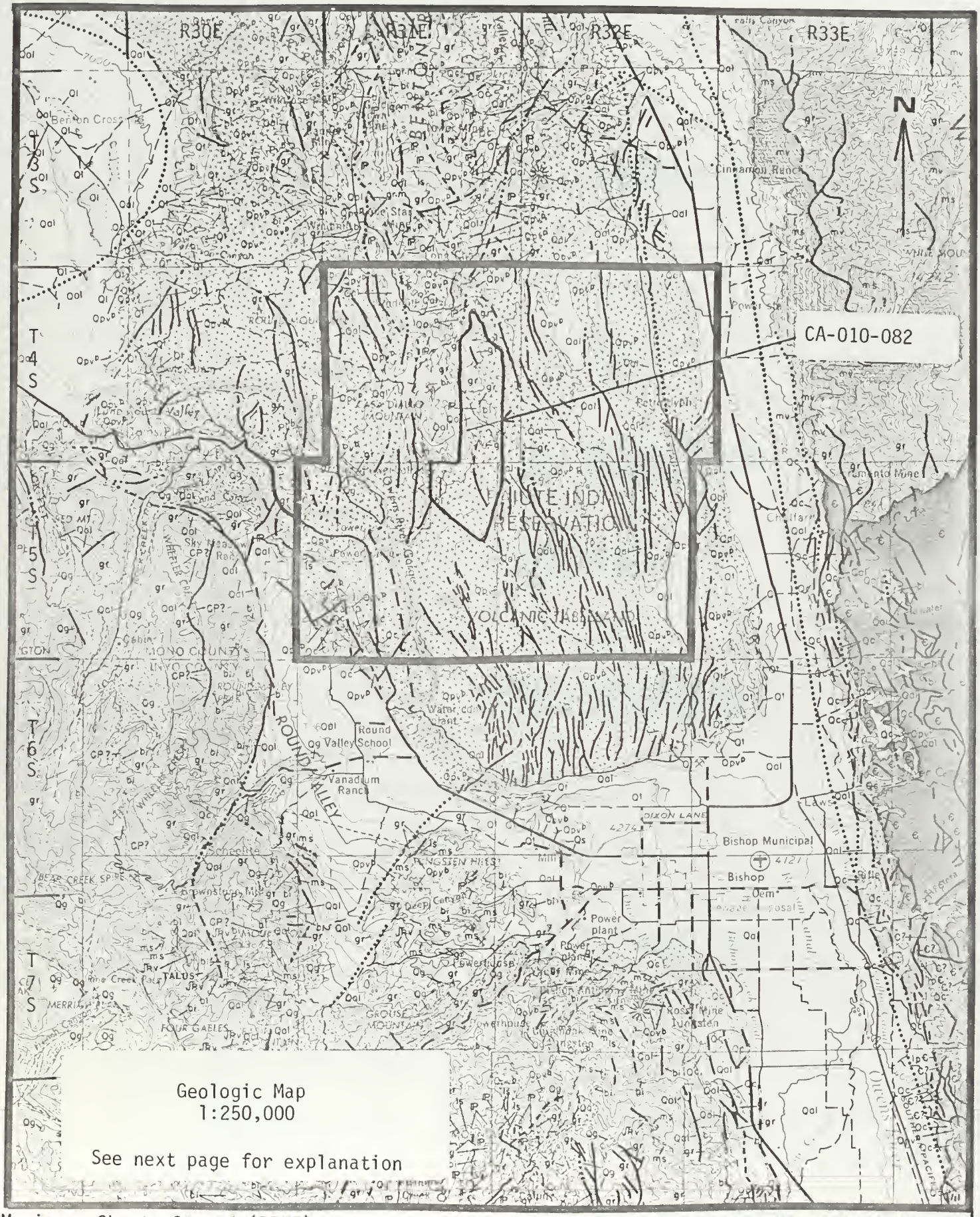
FIGURE 1. GRA INDEX MAP OF REGION 3 1:3,168,000.



Mariposa Sheet

Casa Diablo GRA CA-06

Figure 2



Mariposa Sheet, Strand (1967)

Casa Diablo GRA CA-06

Figure 3

EXPLANATION

SEDIMENTARY AND METASEDIMENTARY ROCKS

CENOZOIC

QUATERNARY

Recent

Qs	Dune sand
Qal	Alluvium
Qsc	Stream channel deposits
Qf	Fan deposits
Qb	Basin deposits

GREAT VALLEY

Qst	Salt deposits
Ql	Quaternary lake deposits
Qg	Glacial deposits
Qt	Quaternary nonmarine terrace deposits

Pleistocene

Qm	Pleistocene marine and marine terrace deposits
Qc	Pleistocene nonmarine
QP	Plio-Pleistocene nonmarine

TERTIARY

Pliocene

Pc	Undivided Pliocene nonmarine
Puc	Upper Pliocene nonmarine
Pu	Upper Pliocene marine
Pmlc	Middle and/or lower Pliocene nonmarine
Pml	Middle and/or lower Pliocene marine

Miocene

Mc	Undivided Miocene nonmarine
Muc	Upper Miocene nonmarine
Mu	Upper Miocene marine
Mmc	Middle Miocene nonmarine
Mm	Middle Miocene marine
Ml	Lower Miocene marine

Oligocene

Φc	Oligocene nonmarine
Φ	Oligocene marine

Eocene

Ec	Eocene nonmarine
E	Eocene marine

Paleocene

Epc	Paleocene nonmarine
Ep	Paleocene marine

IGNEOUS AND META-IGNEOUS ROCKS

Qrv — Recent volcanic: Q_{rv}^{r} —rhyolite; Q_{rv}^{a} —andesite; Q_{rv}^{b} —basalt; Q_{rv}^{p} —pyroclastic rocks

Qpv — Pleistocene volcanic: Q_{pv}^{r} —rhyolite; Q_{pv}^{a} —andesite; Q_{pv}^{b} —basalt; Q_{pv}^{p} —pyroclastic rocks

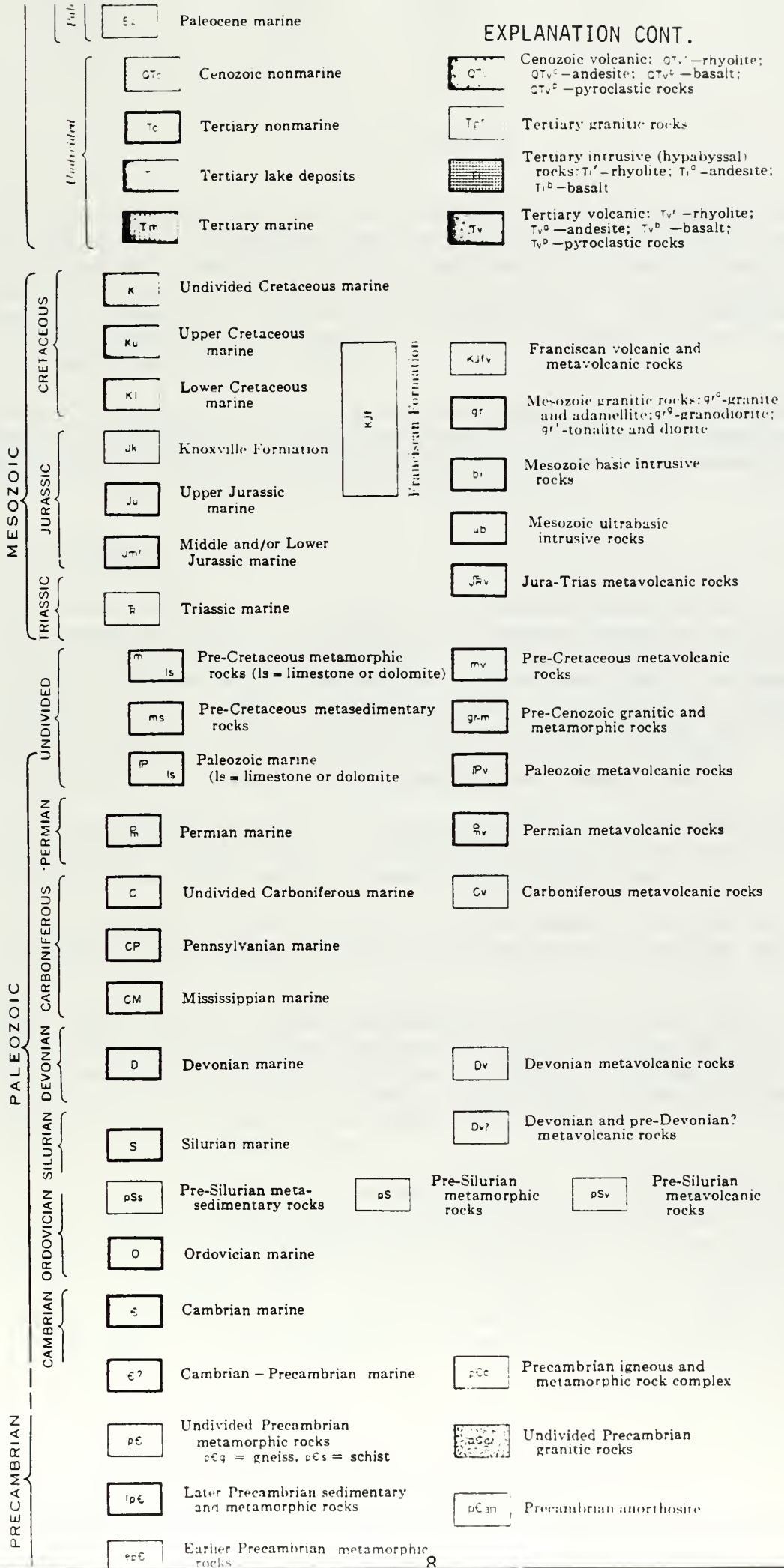
Quaternary and/or Pliocene cinder cones

Pv — Pliocene volcanic: P_{v}^{r} —rhyolite; P_{v}^{a} —andesite; P_{v}^{b} —basalt; P_{v}^{p} —pyroclastic rocks

Mv — Miocene volcanic: M_{v}^{r} —rhyolite; M_{v}^{a} —andesite; M_{v}^{b} —basalt; M_{v}^{p} —pyroclastic rocks

Φv — Oligocene volcanic: Φ_{v}^{r} —rhyolite; Φ_{v}^{a} —andesite; Φ_{v}^{b} —basalt; Φ_{v}^{p} —pyroclastic rocks

Ev — Eocene volcanic: E_{v}^{r} —rhyolite; E_{v}^{a} andesite; E_{v}^{b} —basalt; E_{v}^{p} —pyroclastic rocks


Paleocene marine
Undivided
Cenozoic nonmarine
Tertiary nonmarine
Tertiary lake deposits
Tertiary marine
MESOZOIC
CRETACEOUS
JURASSIC
TRIASSIC
Undivided Cretaceous marine
Upper Cretaceous marine
Lower Cretaceous marine
Knoxville Formation
Upper Jurassic marine
Middle and/or Lower Jurassic marine
Triassic marine
Franciscan Formation
UNDIVIDED
Pre-Cretaceous metamorphic rocks (ls = limestone or dolomite)
Pre-Cretaceous metasedimentary rocks
Paleozoic marine (ls = limestone or dolomite
PERMIAN
Permian marine
PALEOZOIC
CARBONIFEROUS
Undivided Carboniferous marine
Pennsylvanian marine
Mississippian marine
DEVONIAN
Devonian marine
SILURIAN
Silurian marine
Pre-Silurian meta-sedimentary rocks
ORDOVICIAN
Ordovician marine
CAMBRIAN
Cambrian marine
Cambrian – Precambrian marine
PRECAMBRIAN
Undivided Precambrian metamorphic rocks
pCg = gneiss, pCs = schist
Later Precambrian sedimentary and metamorphic rocks
Earlier Precambrian metamorphic rocks
EXPLANATION CONT.
Cenozoic volcanic: QTv^r –rhyolite; QTv^a –andesite; QTv^b –basalt; QTv^p –pyroclastic rocks
Tertiary granitic rocks
Tertiary intrusive (hypabyssal) rocks: Ti^r –rhyolite; Ti^a –andesite; Ti^b –basalt
Tertiary volcanic: Tv^r –rhyolite; Tv^a –andesite; Tv^b –basalt; Tv^p –pyroclastic rocks
Franciscan volcanic and metavolcanic rocks
Mesozoic granitic rocks: gr^a-granite and adamellite; gr^g-granodiorite; gr^t-tonalite and diorite
Mesozoic basic intrusive rocks
Mesozoic ultrabasic intrusive rocks
Jura-Trias metavolcanic rocks
Pre-Cretaceous metavolcanic rocks
Pre-Cenozoic granitic and metamorphic rocks
Paleozoic metavolcanic rocks
Permian metavolcanic rocks
Carboniferous metavolcanic rocks
Devonian metavolcanic rocks
Devonian and pre-Devonian? metavolcanic rocks
Pre-Silurian metamorphic rocks
Pre-Silurian metavolcanic rocks
Precambrian igneous and metamorphic rock complex
Undivided Precambrian granitic rocks
Precambrian anorthosite

II. GEOLOGY

The Casa Diablo GRA in southern Mono County is situated within a large graben on the western edge of the Basin and Range Province. The northwestern portion of the study area is the southern end of the Benton Range, a relatively uplifted block of Paleozoic metamorphic rocks and Cretaceous intrusives. The remainder of the area is predominantly volcanic tablelands formed by the deposition of the Quaternary Bishop Tuff.

Northwest trending Pliocene Basin and Range faults have produced the generally moderate topography especially in the Benton Range. Recent fault activity is evidenced by smaller displacements in the Bishop Tuff and recent alluvial deposits.

1. PHYSIOGRAPHY

The Casa Diablo GRA, located in southern Mono County, is on the western edge of the Basin and Range Province near the Sierra Nevada Province border. It lies within a large graben bounded by the White Mountains to the east and the Sierra Nevadas to the west. The study area contains the southern portion of the north-south-trending, relatively uplifted, Benton Range and the gently south-sloping "volcanic tablelands" in the south (Rinehart and Ross, 1957).

The topography of much of the area is moderate with altitudes ranging from 4500 feet in Hammil Valley on the east to about 7900 feet at the peak of Casa Diablo Mountain.

Chidago Canyon in the north and the Owens River Gorge in the southwest have been cut into the Quaternary Bishop Tuff.

There are no year round flowing streams in the study area. The Owens River in the southwest portion of the GRA is periodically dry below the dam at Crowley Lake to the northwest due to the diversion of water to power plants of the Los Angeles Department of Water and Power. Two of these power plants are located in the Owens River Gorge in the southwest portion of the study area.

Late Pliocene Basin and Range faulting is responsible for much of the present topography in the northwest portion of the study area. The remainder of the surface is a gently sloping volcanic terrane formed by the deposition of the Bishop Tuff. Since the extrusion of the Bishop Tuff, recent fault activity has modified the landscape to a minor degree. Fault scarps are abundant in the Bishop Tuff and have an average throw of 100 feet.

2. ROCK UNITS

The oldest rocks in the study area are upper Precambrian or lower Paleozoic marine sediments in the Benton Range which have been metamorphosed by Cretaceous intrusions to biotite-quartz hornfels, quartz-mica phyllite and quartz-sericite hornfels (Rinehart and Ross, 1957). The sediments are the hosts for tungsten deposits and some gold veins in the area.

Small bodies of diorite-gabbro were emplaced in the early Cretaceous followed by the intrusion of the Benton Range granodiorite, the Wheeler Crest quartz monzonite, the Casa Diablo granite and isolated bodies of alaskite (Rinehart and Ross, 1957). These intrusive bodies provided the mineralizing solutions that formed base and precious metal deposits.

A swarm of porphyritic rhyolite and aplite dikes sills, and small masses related to the cooling intrusions were emplaced along regional northwest trending structures during the late Cretaceous.

The next oldest formation in the study area is an unnamed flow of Tertiary basalt which crops out in patches in the northwest and along the Owens River Gorge (Putnam, 1952).

The Bishop Tuff, deposited during the Pleistocene, is the youngest volcanic sequence in the area and covers a predominant portion of the surface area (Dalrymple and others, 1965). Where thick vertical sections are exposed, it is possible to subdivide the tuff into five units based on compaction, color and columnar jointing. Pumiceous units have been mined for pumice.

3. STRUCTURAL GEOLOGY AND TECTONICS

The oldest structures preserved in the study area are pre-batholith folds and faults in the Paleozoic metamorphic rocks of the Benton Range. This deformation occurred during a period of regional compression which probably took place during the Triassic.

Most of the Benton Range is bounded by large north-northwest-trending Pliocene Basin and Range faults. Movement along these faults is still occurring as shown by local displacements of the Quaternary Bishop Tuff along their trend (Rinehart and others, 1956).

The more recent faults that are prominent in the Bishop Tuff trend north and are mostly downthrown to the west. The average throw of these faults is less than 100 feet. These faults are similar in trend and direction of movement to most of the older faults in the Benton Range, and may represent renewed movement along pre-Tertiary faults in the underlying basement rocks.

4. PALEONTOLOGY

The Casa Diablo GRA covers a terrane of predominantly Pleistocene pyroclastics of the Bishop tuff, with small areas of metamorphosed sediments, Mesozoic granitic rocks and Quaternary alluvium, gravels, and dune sands. Fossils are not to be expected in any of these units.

5. HISTORICAL GEOLOGY

During the late Precambrian or early Paleozoic, sequences of marine clastic and carbonate rocks were deposited. These sediments were folded and faulted by regional compressional forces during the Triassic.

Intrusive bodies of diorite and granitic plutons related to the Sierra Nevada batholith were emplaced during the Cretaceous, metamorphosing the sediments to phyllites and hornfels and introducing mineralizing solutions that formed tungsten and gold deposits.

During the late Cretaceous swarms of aplite and rhyolite dikes were intruded along north-northwest zones of weakness.

Volcanism began during the Tertiary with the extrusion of basalt flows in the area. Basin and Range faulting began after the extrusion of the basalt during the late Pliocene. This faulting has been more or less continuous but on a smaller scale to the present.

A period of erosion is evidenced by the irregular low relief surface on which the Bishop Tuff was deposited during the Quaternary. The Bishop Tuff has numerous small fault displacements from recent tectonic activity (Dalrymple and others, 1965), and pumice has been produced from it.

III. ENERGY AND MINERAL RESOURCES

A. METALLIC MINERAL RESOURCES

1. Known Mineral Deposits

The northwestern quarter of the Casa Diablo GRA covers the southern end of the Chidago mining district. The district consists of a dozen or more productive mines rather widely scattered over T 3 S, R 31 E, and T 4 S, R 31 E. Rinehart and Ross (1956) estimate total precious metal production of the district as probably less than $1,000,000, while the Black Rock mine, three miles north of the GRA, produced at least 275,000 tons of tungsten ore averaging about 0.5% WO_3. Tungsten is a strategic and critical metal.

Within the GRA are the Casa Diablo mine (Sec. 21, T 4 S, R 31 E), credited with something over $100,000 in gold, silver and base metals, and the Beckman mine (Sec. 2, T 4 S, R 31 E) with somewhat less than $100,000 in the same metals.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Rinehart and Ross (1956) show a dozen prospect pits and shafts in an irregular line extending two miles south from the Casa Diablo mine, half a mile west of WSA 010-082. No information is available as to their nature, but since they are in the same granitic body as the Casa Diablo mine they probably are on similar occurrences of gold-silver-base metal veins.

Near the Beckman mine are a couple of prospects, one labelled the Chance mine by Rinehart and Ross (1956) and indicated as having produced some lead and silver.

Near the west edge of Sec. 2, T 5 S, R 31 E on the Casa Diablo Mountain topographic quadrangle, is a prospect symbol within the WSA. In and near the northwest corner of Sec. 14, T 4 S, R 32 E are prospect and adit symbols, one of which may be within the WSA. All of these are in granitic rocks and are probably on quartz veins similar to those of the Casa Diablo mine.

3. Mining Claims

No patented claims were found in the GRA in our search of the BLM records, but Tucker (1927) refers to two patented claims at the Casa Diablo mine.

There are several dozen unpatented mining claims in the GRA. Most of them are in the vicinity of the known prospects -- near the Beckman mine and near and south of the Casa Diablo mine. There are claims in the western one-half of Sec. 35, T 4 S, R 31 E, within WSA 010-082; these are in an area underlain by the granite of the Casa Diablo mine and probably are on occurrences of similar mineralization.

4. Mineral Deposit Types

The two mines and the several scattered prospects in the pre-Tertiary terrane are quartz veins that contain precious and base metals. They are mesothermal, formed during the final stages of the Mesozoic intrusive activity. All descriptions indicate that they are narrow and that the ore shoots in them are small.

No tungsten occurrences are known in the Casa Diablo GRA, but the important Black Rock tungsten mine lies only a few miles north of the GRA. The Black Rock deposit is pyrometasomatic, scheelite-bearing tactite body in metasediments of Paleozoic(?) age that have been intruded by several bodies of generally granitic rocks of Mesozoic age. Most of the same granitic rocks are exposed in the small area of pre-Tertiary rocks in the northwest part of the Casa Diablo GRA, and some metasediments also are exposed although none of them are of the calcareous unit that hosts the Black Rock deposit.

5. Mineral Economics

The mesothermal quartz veins with base and precious metals are so narrow and have such small ore shoots that they do not make attractive targets for most mining companies, but during times of high metal prices may be mined by small companies or individuals.

There is nothing to indicate the presence of tungsten deposits in the GRA close enough to the surface to be mined open-pit as the Black Rock deposit was. However, such a deposit probably could be mined underground, given high grade and a good tungsten price. If any such deposits are found under the Tertiary and Quaternary volcanic cover, they may be worth mining.

More than half of all tungsten used is in the form of tungsten carbide, a hard and durable material used in cutting tools, wear-resistant surfaces and hard-faced welding rods. Lesser quantities are used in alloy steels, in light bulb filaments, and in chemicals. World production of tungsten is nearly 100 million pounds annually, of which the United States produces somewhat

more than six million pounds, while using more than 21 million pounds. The shortfall is imported from Canada, Bolivia, Thailand and Mainland China, as well as other countries. Tungsten is a strategic and critical metal. United States demand is projected to about double by the year 2000, and most of the additional supply will probably be imported, because large reserves are in countries in which profitability is not a factor -- they need foreign exchange, and therefore sell at a price that few domestic mines can match. Tungsten prices F.O.B. mine are quoted for "short ton units", which are the equivalent of 20 pounds of contained tungsten. At the end of 1982 the price of tungsten was about $80 per short ton unit.

The major use of gold is for storing wealth. It is no longer used for coinage because of monetary problems, but many gold "coins" are struck each year for sale simply as known quantities of gold that the buyer can keep or dispose of relatively easily. The greatest other use of gold is in jewelry, another form of stored wealth. In recent years industrial applications have become increasingly important, especially as a conductor in electronic instrumentation. In the United States and some other countries gold is measured in troy ounces that weigh 31.1 grams -- twelve of which make one troy pound. Annual world production is about 40 million ounces per year, of which the United States produces somewhat more than one million ounces, less than one-fourth of its consumption, while the Republic of South Africa is by far the largest producer at more than 20 million ounces per year. World production is expected to increase through the 1980s. For many years the price was fixed by the United States at $35 per ounce, but after deregulation the price rose to a high of more than $800 per ounce and then dropped to the neighborhood of $400 per ounce. At the end of 1982 the price was $460.50 per ounce.

The major uses of silver are in photographic film, sterlingware, and increasingly in electrical contacts and conductors. It is also widely used for storage of wealth in the form of jewelry, "coins" or bullion. Like gold it is commonly measured in troy ounces, which weigh 31.1 grand grams, twelve of which make one troy pound. World production is about 350 million ounces per year, of which the United States produces about one-tenth, while it uses more than one-third of world production. About two-thirds of all silver is produced as a byproduct in the mining of other metals, so the supply cannot readily adjust to demand. It is a strategic metal. Demand is expected to increase in the next decades because of growing industrial use. At the end of 1982 the price of silver was $11.70 per ounce.

The largest use for lead is in electrical storage

batteries, the second being a gasoline antiknock additive. It has many other uses, however, including radiation shielding, solders, numerous chemical applications, and in construction. About four million metric tons of lead are produced in the world annually. The United States produces about half a million tons per year, and recovers about the same amount from scrap -- much of it through the recycling of old batteries. It imports about one-quarter of a million tons. Lead is classified as a strategic minerals. Demand is projected to increase somewhat in the next couple of decades, but environmental concerns will limit the increase. The United States has large ore reserves that are expected to last well beyond the end of this century at current production rates even without major new discoveries. At the end of 1982 the price was about 22 cents per pound.

B. NONMETALLIC MINERAL RESOURCES

1. Known Mineral Deposits

In the southwestern half of Sec. 12, T 4 S, R 32 E, at the extreme eastern edge of the GRA, on the White Mountain Peak 15-minute topographic quadrangle is a quarry symbol labelled Sandpit. Since the late 1950's fine silt, that is predominantly the mineral pyrophyllite, has been mined here. It is air separated to mostly minus 325 mesh and shipped, under the trade name Siltex, to the Los Angeles area as a filler in specialty asphalt mixes (A. Baker III, personal communication.)

2. Known Prospects, Mineral Occurrences and Mineralized Areas

In the northwest 1/4 of Sec. 10, T 4 S, R 31 E Rinehart and Ross (1956) show a quarry symbol indicated as being in pumice. Rather suprisingly, considering the large expanses of Bishop tuff exposed in the GRA, there seem to be no other pumice pits.

3. Mining Claims, Leases and Material Sites

In the northeast corner of the GRA are a number of claims, and it appears that much of Sec. 13, T 4 S, R 32 E is claimed. This is the vicinity of the Siltex mine and the claims may well be located to cover the known area of this material.

4. Mineral Deposit Types

The Siltex deposit near the east border of the GRA

displays some bedding, and probably is a lakebed deposited in an ephemeral lake that once occupied Hammil Valley. It can be considered a clay. The operators of the deposit believe that most of the material is finely-divided pyrophyllite eroded from the canyons in the White Mountains a very few miles to the east; the geography fits with this interpretation.

One pumice quarry is known in the GRA, in Sec, 10, T 4 S, R 31 E. The apparent lack of them elsewhere in the GRA, despite the fact that they are common in the general region, suggests that this part of the Bishop tuff is not favorable for pumice deposits.

5. Mineral Economics

The Siltex deposit evidently is one of the rather special industrial mineral deposits in the region that can stand the high transportation cost to the Los Angeles market, since it has been mined for at least twenty years.

There are several major varieties of clay, differing both in their mineralogy and their uses, and some materials that mineralogically are clay are called by other names, while some that technically are not clay are called clay. Large amounts of white clay (kaolin) are used as filler in paper to produce the glossy sheen of magazine pages. Even larger quantities of common clay are used in making bricks, drain tile, and other construction products. Certain clays are used extensively in ceramics and in refractory materials. Minor uses include drilling muds, foundry sands, purifying materials for oils, and a great many more. The United States uses about 50 million tons of clays annually, nearly all of it produced domestically. Consumption is forecast to about double by the year 2000, with production increasing in amount the same proportion. The price of clay varies widely depending on the kind of material: the average price is a little lower than $20 per ton, but common clay is valued at about $5 per ton while the highest-priced clay, kaolin, averages about $65 per ton.

For statistical purposes pumice, volcanic cinder and scoria are treated together because in most applications they are interchangeable; the word "pumice" as used here includes the other materials. Because of its porous nature and resultant light weight (some pumice will float on water) about 40% of all pumice production is used as aggregate in making light-weight concrete for construction purposes. An equal amount is used as aggregate in road construction. A small amount is used in abrasives, while the remainder is used, mostly in finely-ground form, in a multitude of applications such as absorbents, carriers for insecticides, decolorizers and purifying agents, fillers

and extenders for paints, and many others. United States consumption is about 4.5 million short tons annually, nearly all of which is produced domestically and most of which is produced within a very few hundred miles of the point of use because it is a high-volume, low-unit-price material. A small quantity of pumice for specialized uses is imported. United States demand for pumice is forecast to more than double by the year 2000, with domestic production keeping up with demand. In recent years the F.O.B. mine price for pumice as such has been about $4 per ton, while the price for the somewhat more common volcanic cinders has been about $3 per ton.

C. ENERGY RESOURCES

Uranium and Thorium Resources

1. Known Mineral Deposits

There are no known uranium or thorium deposits within or near the WSA or the GRA.

2. Known Prospects, Mineral Occurrences and Mineralized Areas

Radioactive occurrences are indicated on the Land Classification and Mineral Occurrence Map included at the back of the report.

There are no known uranium or thorium prospects or occurrences within the WSA or the GRA. There are two uranium occurrences north of the GRA though no production has been recorded from these occurrences. Uranium is associated with a quartz monzonite intrusion at the Banner gold mine in Sec. 18, T 3 S, R 31 E and there is an undescribed uranium occurrence at the Claw claim in T 2 S, R 33 E on the west flank of the White Mountains (Minobras, 1978).

3. Mining Claims

There are no known uranium or thorium claims or leases within the WSA or the GRA.

4. Mineral Deposit Types

The lack of known occurrences of uranium and thorium in the area prevents a determination of the deposit types.

5. Mineral Economics

Uranium and thorium would appear to be of little economic importance within the WSA and the GRA as there are no known occurrences of these minerals in the area.

Uranium in its enriched form is used primarily as fuel for nuclear reactors, with lesser amounts being used in the manufacture of atomic weapons and materials which are used for medical radiation treatments. Annual western world production of uranium concentrates totaled approximately 57,000 tons in 1981, and the United States was responsible for about 30 percent of this total, making the United States the largest single producer of uranium (American Bureau of Metal Statistics, 1982). The United States ranks second behind Australia in uranium resources based on a production cost of $25/pound or less. United States uranium demand is growing at a much slower rate than was forecast in the late 1970s, because the number of new reactors scheduled for construction has declined sharply since the accident at the Three Mile Island Nuclear Plant in March, 1979. Current and future supplies were seen to exceed future demand by a significant margin and spot prices of uranium fell from $40/pound to $25/pound from January, 1980 to January, 1981 (Mining Journal, July 24, 1981). At present the outlook for the United States uranium industry is bleak. Low prices and overproduction in the industry have resulted in the closures of numerous uranium mines and mills and reduced production at properties which have remained in operation. The price of uranium at the end of 1982 was $19.75/pound of concentrate. Uranium and thorium would appear to be of little economic importance within the WSA and the GRA as there are no known occurrences of these minerals in the area.

Thorium is used in the manufacture of incandescent gas mantles, welding rods, refractories, as fuel for nuclear power reactors and as an alloying agent. The principal source of thorium is monazite which is recovered as a byproduct of titanium, zirconium and rare earth recovery from beach sands. Although monazite is produced from Florida beach sands, thorium products are not produced from monazite in the United States. Consequently, thorium products used in the United States come from imports, primarily from France and Canada, and industry and government stocks. Estimated United States consumption of thorium in 1980 was 33 tons, most of which was used in incandescent lamp mantles and refractories (Kirk, 1980b). Use of thorium as nuclear fuel is relatively small at present, because only two commercial thorium-fueled reactors are in operation. Annual United States demand for thorium is projected at 155 tons by 2000 (Kirk, 1980a). Most of this growth is forecast to occur in nuclear power reactor usage, assuming that six to ten

thorium-fueled reactors are on line by that time. The United States and the rest of the world are in a favorable position with regard to adequacy of thorium reserves. The United States has reserves estimated at 218,000 tons of ThO_2 in stream and beach placers, veins and carbonatite deposits (Kirk, 1982); and probable cumulative demand in the United States as of 2000 is estimated at only 1800 tons (Kirk, 1980b). The price of thorium oxide at the end of 1981 was $16.45 per pound.

Oil and Gas Resources

There are no oil and gas fields, hydrocarbon shows in wells, or surface seeps in the region; nor are there any Federal oil and gas leases in the immediate region. Intrusive and extrusive igneous rocks are the predominant strata present; no source rocks are present which would favor the generation of petroleum.

There is no oil and gas lease map, nor is there an oil and gas occurrence and classification map in the report.

Geothermal Resources

1. Known Geothermal Resources

   There are no known geothermal deposits within the Casa Diablo GRA.

2. Known Prospects, Geothermal Occurrences, and Geothermal Areas

   The Casa Diablo GRA has no recorded thermal springs or wells, but is less than five miles southeast of the Long Valley geothermal resource area which is a collapsed caldera underlain by a slowly cooling magma that is presumed to be the heat source for numerous surface thermal manifestations such as springs and fumeroles. Long Valley is known or inferred to be underlain at shallow (less than 1,000 meters) by thermal water of sufficient temperature for direct heat application. In the eastern portion of the caldera, closest to the Casa Diablo GRA, three unnamed spring areas have waters of 22° to 53°C (NOAA, 1980). These thermal manifestations are shown on the Geothermal Occurrence and Land Classification Map at the back of the report.

   On structural trend 15 miles to the south of the GRA in Owens Valley, 51°C Keough Hot Spring flows at 2000 l/min., and unnamed springs on the opposite side of the valley are 29°C (NOAA, 1980).

3. Geothermal Leases

The only recorded Federal geothermal leasing in the area is a 40 square mile lease block on the eastern rim of the Long Valley caldera. These leases share a six mile long common boundary with the Casa Diablo GRA, and are contiguous with the eastern edge of the Mono-Long Valley KGRA (see Geothermal Lease Map).

4. Geothermal Deposit Types

There are no geothermal deposits within the Casa Diablo area.

5. Geothermal Economics

Because there are no geothermal deposits or other thermal manifestations within the GRA, there is no direct basis on which to base consideration of the mineral economics.

Geothermal resources are utilized in the form of hot water or steam normally captured by means of drilling wells to a depth of a few feet to over 10,000 feet in depth. The fluid temperature, sustained flow rate and water chemistry characteristics of a geothermal reservoir determine the depth to which it will be economically feasible to drill and develop each site.

Higher temperature resources (above 350°F) are currently being used to generate electrical power in Utah and California, and in a number of foreign countries. As fuel costs rise and technology improves, the lower temperature limit for power will decrease appreciably -- especially for remote sites.

All thermal waters can be beneficially used in some way, including fish farming (68°F), warm water for year around mining in cold climates (86°F), residential space heating (122°F), greenhouses by space heating (176°F), drying of vegetables (212°F), extraction of salts by evaporation and crystallization (266°F), and drying of diatomaceous earth (338°F).

Unlike most mineral commodities remoteness of resource location is not a drawback. Domestic and commercial use of natural thermal springs and shallow wells in the Basin and Range province is a historical fact for over 100 years.

Development and maintenance of a resource for beneficial use may mean no dollars or hundreds of millions of dollars, depending on the resource characteristics, the end use and the intensity or level of use.

D. OTHER GEOLOGICAL RESOURCES

No other geological resources have been recognized in the GRA.

E. STRAGETIC AND CRITICAL MINERALS AND METALS

A list of strategic and critical minerals and metals provided by the BLM was used as a guideline for the discussion of strategic and critical materials in this report.

The Stockpile Report to the Congress, October 1981-March 1982, states that the term "strategic and critical materials" refers to materials that would be needed to supply the industrial, military and essential civilian needs of the United States during a national emergency and are not found or produced in the United States in sufficient quantities to meet such need. The report does not define a distinction between strategic and critical minerals.

No strategic or critical minerals or metals are known in WSA CA 010-082. There is some potential for tungsten, a strategic metal, in the older rocks beneath the cover of Tertiary volcanic rocks and Quaternary alluvium.

IV. LAND CLASSIFICATION FOR GEM RESOURCES POTENTIAL

The Rinehart and Ross (1957) geologic map at 1:62,500 covers much of the GRA and all of the WSA. The geological data here is excellent except that hydrothermal alteration, if it is present, was not mapped. The Rinehart and Ross (1956) map provides excellent information on the distribution and nature of mineral occurrences. The eastern part of the GRA is covered by the geologic map at 1:62,500 of Crowder and Sheridan (1972). This map provides excellent coverage of rock types and structure; it is unlikely that there is alteration in this area that has significance in regard to metallic resources. Specifically with respect to the WSA and its environs, the quantity of geologic coverage is ample, the quality is moderate, and data concerning mineral occurrences is good but background data such as alteration and geochemistry are lacking. Overall, our confidence level in the information available is high.

Land classification areas are numbered starting with the number 1 in each category of resources. Metallic mineral land classification areas have the prefix M, e.g. M1-4D. Uranium and thorium areas have the prefix U. Nonmetallic mineral areas have the prefix N. Oil and gas areas have the prefix OG. Geothermal areas have the prefix G. Sodium and potassium areas have the prefix S. The saleable resources are classified under the nonmetallic mineral resource section. Both the Classification Scheme, numbers 1 through 4, and the Level of Confidence Scheme, letters A, B, C and D, as supplied by the BLM are included as attachments to this report. These schemes were used as strict guidelines in developing the mineral classification areas used in this report.

Land classifications have been made here only for the areas that encompass segments of the WSA. Where data outside a WSA has been used in establishing a classification area within a WSA, then at least a part of the surrounding area may also be included for clarification. The classified areas are shown on the 1:250,000 mylars or the prints of those that accompany each copy of this report.

In connection with nonmetallic mineral classification, it should be noted that in all instances areas mapped as alluvium are classified as having moderate favorability for sand and gravel, with moderate confidence, since alluvium is by definition sand and gravel. All areas mapped as principally limestone or dolomite have a similar classification since these rocks are usable for cement or lime production. All areas mapped as other rock, if they do not have specific reason for a different classification, are classified as having low favorability, with low confidence, for nonmetallic mineral potential, since any mineral material can at least be used in construction applications.

1. LOCATABLE RESOURCES

a. Metallic Minerals

WSA CA 010-082

M1-3C. This classification area covers all of the WSA. Its boundary is largely defined by gravimetrics. Pakiser, and others, (1964, Plate 1, Sheet 1) show a gravity low just west of the WSA, which probably indicates a block of pre-Tertiary rocks that has been dropped too deep for mineral exploration in the near future. To the south and east, however, the gentle gravity slope indicates thin cover by Tertiary rocks. Within a mile west and north of the WSA are the productive Casa Diablo, Beckman and Chance gold mines, and a dozen or more prospects. All of these are in the intrusive rocks or metasediments that are the hosts for other mines in the Chidago district, and that underlie the WSA (Rinehart and Ross, 1956). The fact that the rocks are known to be favorable hosts for metallic minerals, and the presence of mines and prospects just outside the WSA are the reasons for the moderate favorability classification and the moderate level of confidence.

b. Uranium and Thorium

WSA CA 010-082

U1-2B. This land classification indicating low uranium and thorium favorability at a low level of confidence covers the WSA and nearly the entire GRA. Most of the area is covered by the Pleistocene Bishop Tuff. Cretaceous granitic rocks crop out on the western side of the WSA. Rhyolite and aplite dikes and sills and isolated alaskites associated with the granitic intrusion may extend into the WSA. All of the above igneous rocks are prospective uranium source and host rocks with the uranium most prospective as vein-type and fracture fill deposits, and as concentrated primary mineralization in the alaskites. There are no uranium or thorium occurrences within the GRA or the WSA though there are two uranium occurrences to the north, one of which is associated with quartz monzonite (Banner gold mine). There are also two aerial radiometric uranium anomalies on the east and west borders of the GRA, south of the WSA (High Life Helicopters, 1980).

Thorium is also prospective in the WSA as primary mineralization in the Cretaceous alaskites (pegmatites) though there are no known thorium occurrences in or near the WSA or the GRA.

c. Nonmetallic Minerals

WSA CA 010-082

N1-2B. This classification area covers all of the WSA. There are no nonmetallic occurrences in the WSA or close to it (except one pumice occurrence a couple of miles away. However, all rocks can be used as construction materials, and any mineral material can become an economic nonmetallic mineral if someone can develop a use for its particular physical and chemical properties.

2. LEASABLE RESOURCES

a. Oil and Gas

WSA CA 010-082

OG1-1D. There has been no serious oil and gas exploration, nor are there any recorded occurrences of oil and gas in this westernmost sector of the Basin and Range province where it meets the Sierra Nevadas. The geological environment -- intrusive and intruded rocks and volcanics -- is not favorable for oil and gas accumulations.

b. Geothermal

WSA CA 010-082

G1-3B. While there is no direct evidence of a geothermal resource, the entire GRA is on the eastern edge of the east-west trending Long Valley caldera. Under this collapsed structure there is a slowly cooling magma which is believed to provide the heat for the high temperature resource. Except for the core of Casa Diablo Mountain, the entire GRA is underlain by an intricately faulted Pleistocene volcanic tableland. This volcanic series extends continuously westward, and is found throughout the Long Valley elliptical structure. In addition, the leasing pattern indicates support for this continuity eastward to at least the western edge of the Casa Diablo GRA. The nearby heat source and the numerous faults provide a moderately favorable environment for geothermal resources, with a low level of confidence because no hot springs are known in the area.

c. Sodium and Potassium

WSA CA 010-082

S1-1D. The geological environment has no favorability for sodium or potassium resources.

3. SALEABLE RESOURCES

Saleable resources have been covered in connection with nonmetallic minerals.

V. RECOMMENDATIONS FOR ADDITIONAL WORK

Classification area M1-3C should be reconnoitered to determine if there is any hydrothermal alteration that might lead to mineralized areas. If hydrothermal alteration is found, it should be mapped. The existing geological mapping covers rock types well, but it appears that alteration, if there is any, was not addressed as part of the mapping.

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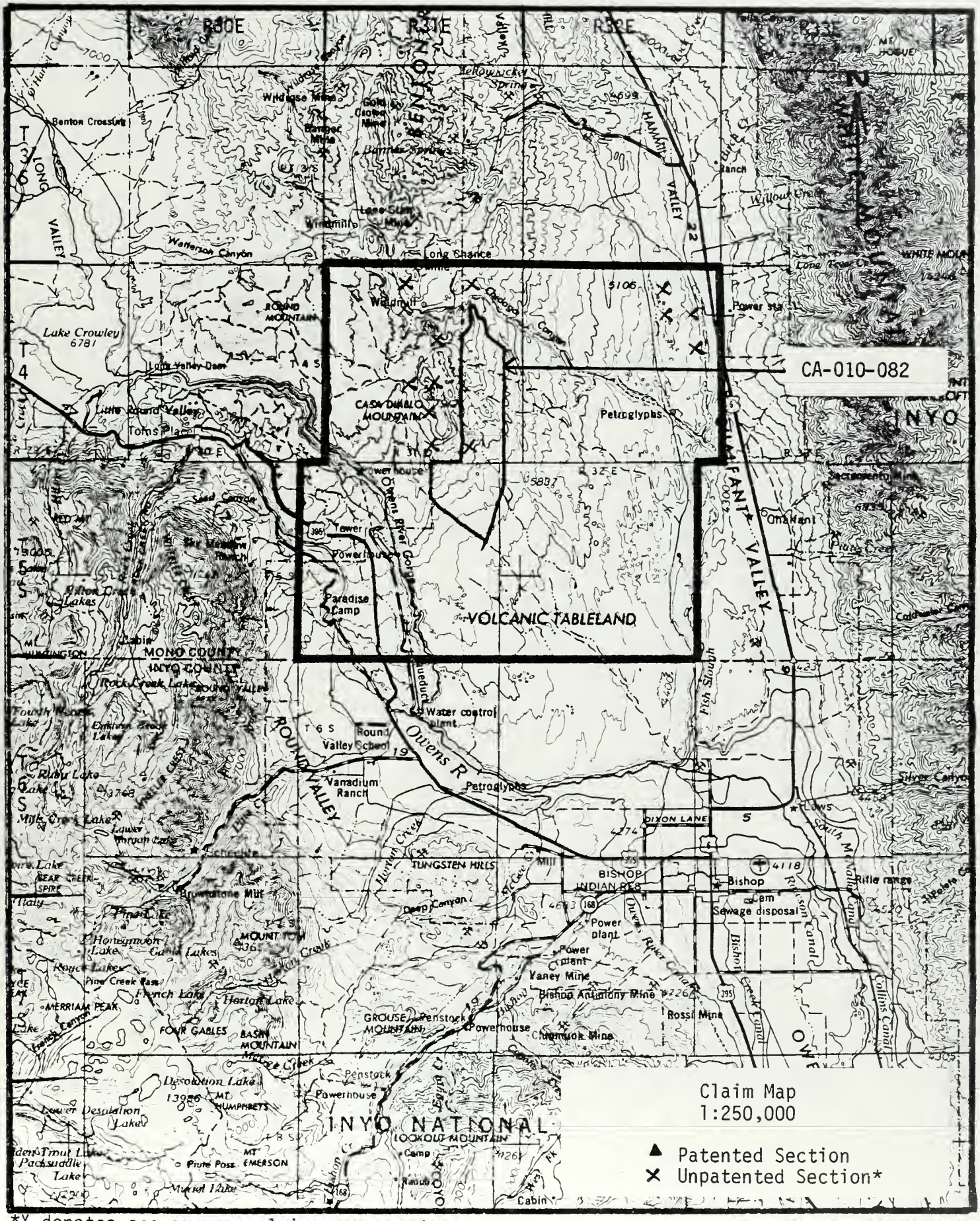
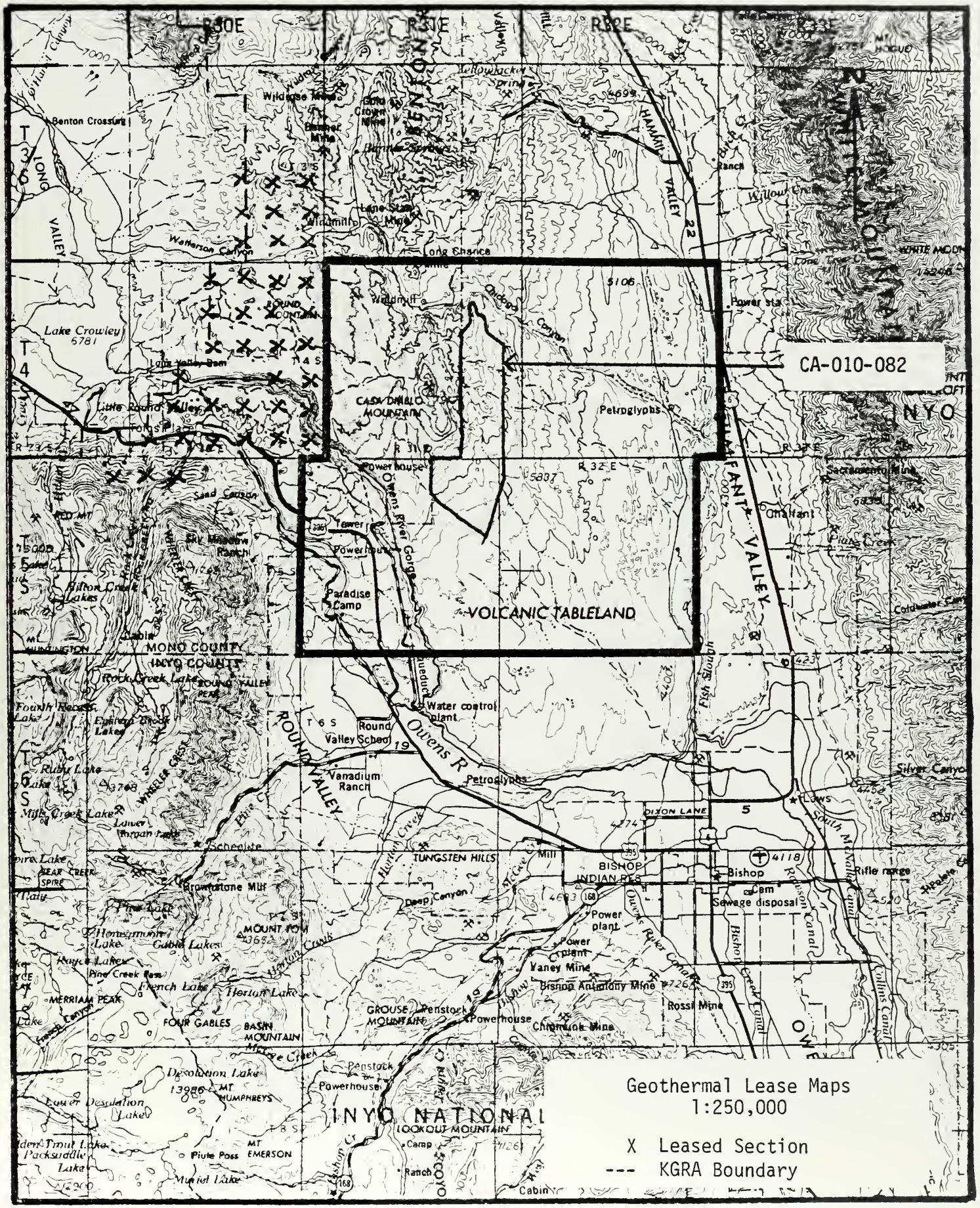


*X denotes one or more claims per section

Casa Diablo GRA CA-06



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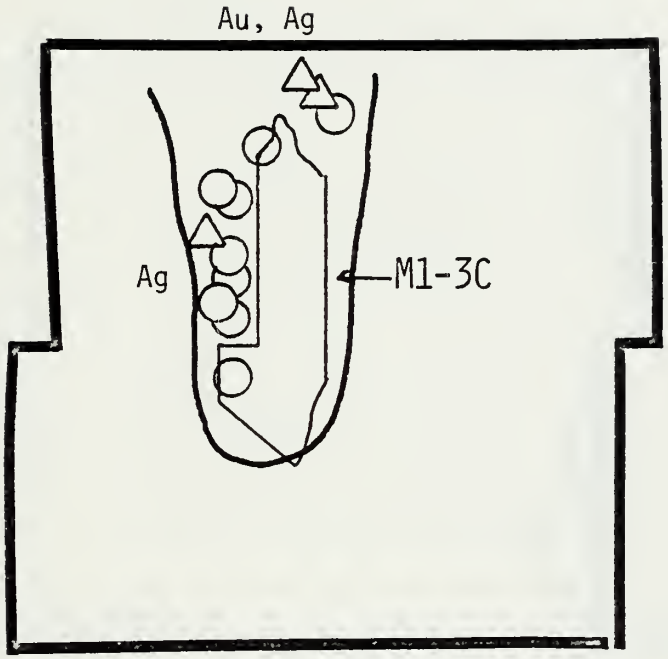


EXPLANATION

△ Mine, commodity

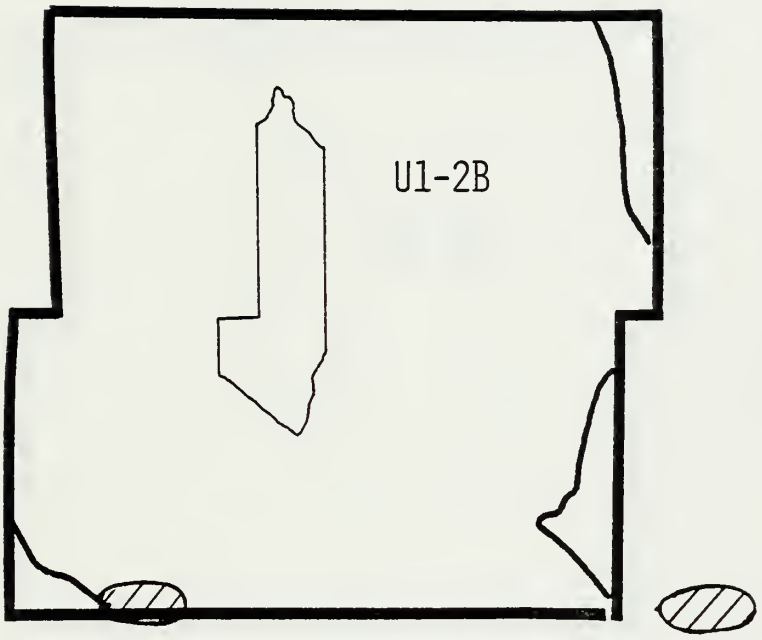
○ Occurrence, commodity

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Metallics

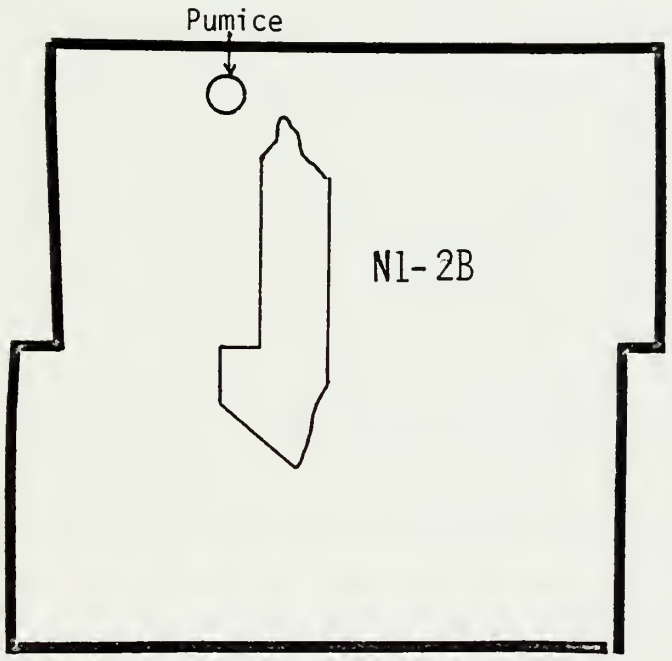
Casa Diablo GRA CA-06
Scale 1:250,000



EXPLANATION

- Uranium Occurrence
- Aerial radiometric uranium anomaly
- Land Classification Boundary
- WSA Boundary

Land Classification - Mineral Occurrence Map/Uranium Casa Diablo GRA CA-06
Scale 1:250,000



EXPLANATION

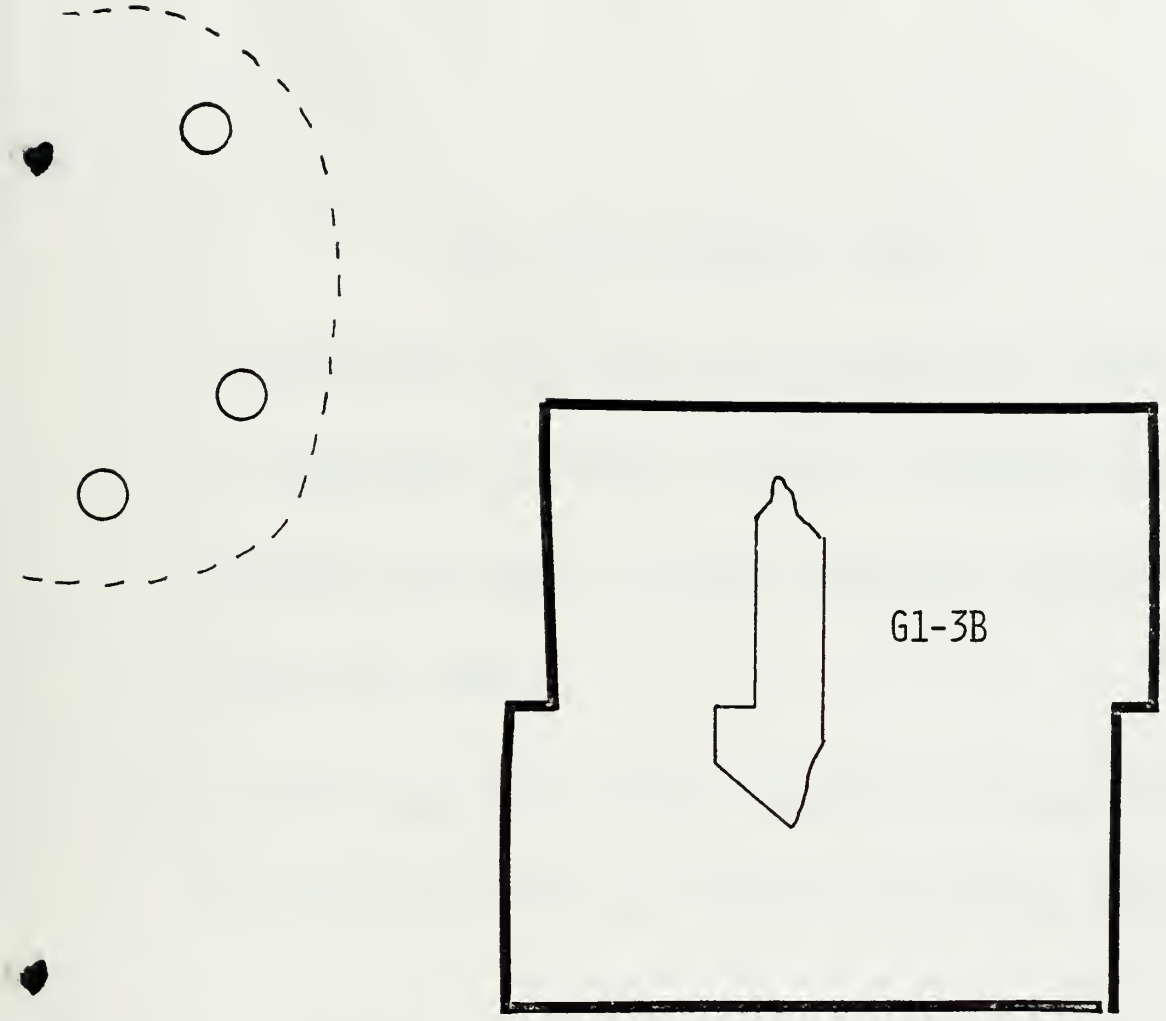
○ Occurrence, commodity

▬ Land Classification Boundary

—— WSA Boundary

Land Classification - Mineral Occurrence Map/Nonmetallics

Casa Diablo GRA CA-06
Scale 1:250,000



EXPLANATION

Thermal well

Region of high chemical geothermometry

Land Classification Boundary

WSA Boundary

Land Classification - Mineral Occurrence Map/Geothermal

Casa Diablo GRA CA-06
Scale 1:250,000

LEVEL OF CONFIDENCE SCHEME

A. THE AVAILABLE DATA ARE EITHER INSUFFICIENT AND/OR CANNOT BE CONSIDERED AS DIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES WITHIN THE RESPECTIVE AREA.

B. THE AVAILABLE DATA PROVIDE INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

C. THE AVAILABLE DATA PROVIDE DIRECT EVIDENCE, BUT ARE QUANTITATIVELY MINIMAL TO SUPPORT TO REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

D. THE AVAILABLE DATA PROVIDE ABUNDANT DIRECT AND INDIRECT EVIDENCE TO SUPPORT OR REFUTE THE POSSIBLE EXISTENCE OF MINERAL RESOURCES.

CLASSIFICATION SCHEME

1. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES DO NOT INDICATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

2. THE GEOLOGIC ENVIRONMENT AND THE INFERRED GEOLOGIC PROCESSES INDICATE LOW FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

3. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, AND THE REPORTED MINERAL OCCURRENCES INDICATE MODERATE FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

4. THE GEOLOGIC ENVIRONMENT, THE INFERRED GEOLOGIC PROCESSES, THE REPORTED MINERAL OCCURRENCES, AND THE KNOWN MINES OR DEPOSITS INDICATE HIGH FAVORABILITY FOR ACCUMULATION OF MINERAL RESOURCES.

MAJOR STRATIGRAPHIC AND TIME DIVISIONS IN USE BY THE U.S. GEOLOGICAL SURVEY

Erathem or Era	System or Period	Series or Epoch	Estimated ages of time boundaries in millions of years
Cenozoic	Quaternary	Holocene	
		Pleistocene	2-3 [1]
	Tertiary	Pliocene	12 [1]
		Miocene	26 [2]
		Oligocene	37-38
		Eocene	53-54
		Paleocene	65
Mesozoic	Cretaceous [4]	Upper (Late) Lower (Early)	136
	Jurassic	Upper (Late) Middle (Middle) Lower (Early)	190-195
	Triassic	Upper (Late) Middle (Middle) Lower (Early)	225
Paleozoic	Permian [4]	Upper (Late) Lower (Early)	280
	Carboniferous Systems: Pennsylvanian [4]	Upper (Late) Middle (Middle) Lower (Early)	
	Carboniferous Systems: Mississippian [4]	Upper (Late) Lower (Early)	345
	Devonian	Upper (Late) Middle (Middle) Lower (Early)	395
	Silurian [4]	Upper (Late) Middle (Middle) Lower (Early)	430-440
	Ordovician [4]	Upper (Late) Middle (Middle) Lower (Early)	500
	Cambrian [4]	Upper (Late) Middle (Middle) Lower (Early)	570
Precambrian [3]		Informal subdivisions such as upper, middle, and lower, or upper and lower, or younger and older may be used locally.	3,600+ [3]

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[2] Geological Society of London, 1964, The Phanerozoic time-scale; a symposium: Geol. Soc. London, Quart. Jour., v. 120, supp., p. 260-262, for the Miocene through the Cambrian.

[3] Stern, T. W., written commun., 1968, for the Precambrian

[4] Includes provincial series accepted for use in U.S. Geological Survey reports.

Terms designating time are in parentheses. Informal time terms early, middle, and late may be used for the eras, and for periods where there is no formal subdivision into Early, Middle, and Late, and for epochs. Informal rock terms lower, middle, and upper may be used where there is no formal subdivision of a system or of a series.

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